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ON THE BEHAVIOR OF MUTILATED SEEDLINGS*

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The particular form of mutilation of seedlings here considered is that of the removal of the plumule. Several kinds of plants have been treated in this way during the past twelve months. The first of these was the garden radish, representing a small, large-rooted and short-lived plant. Soon after the seedling was above ground the plumule was removed upon alternate rows of plants, while the other rows were left to grow normally. The first thing to observe was the much deeper green of the cotyledons of the de-plumuled plants. This was followed by a remarkable elongation of the petiole and increase in size of the obcordate blade, the former attaining a length of three inches and the latter a breadth of an inch and a half. These cotyledons were raised at an angle of about 45° and the very dark green blade had a thickness nearly double that of the normal cotyledons. A microscopic examination showed that the greater thickness was due to increased size of the cells instead of to a multiplication of the layers. The chlorophyll was excessive and the amount of starch so great as practically to render them black when blanched with alcohol and iodized. The roots grew to nearly market size and had the tests been made with a turnip-shaped sort instead of a long variety, it is very likely that the roots would have been fit for the table.

The second species was the common morning glory [*Ipomoea purpurea* (L.)]. Here the cotyledons are large in the seedling,

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but quickly are lost from sight by the development of the much larger alternate true leaves. After holding on for a few days as a rule, the cotyledons lose their green color and drop from the stem. In the de-plumuled seedlings the petioles at once begin to elongate as was shown to be true with the radish, while the remarkable green develops in the blades that likewise become double, or more, the normal size and are the organs of photosynthesis for the mutilated plant. Their dark green is shared by the long, arched petioles (quite different in this respect from those of the radish) and the hypocotyl. The latter becomes of twice the sectional area of that of the normal plants, which are now several feet high and bearing flowers, and becomes a storehouse for the starch that is robbed of its proper use by the absence of any stem. The root system of the de-plumuled plant is not different from that of the normal specimens.

A third type of plant put to the test was the Hubbard squash, the seedlings of which naturally have large cotyledons. In these the seed-leaves remain near the soil without any apparent elongation of the hypocotyl, but there is a remarkable increase in the size of the cotyledons until they are sometimes four or more inches in length and very odd, to say the least. Normally, the true leaves come forth from the plumule rapidly and owing to their large size the cotyledons are soon out of sight and quickly wither away. Dwarfed squash plants depending entirely upon the cotyledons have been kept in apparently healthy condition for four months, the size remaining practically the same after the first four weeks. These plants, unlike those previously mentioned, need frequent attention, for buds will develop in the axils of the seed leaves, which when removed will be followed by others without any determined number. If left undisturbed a whole thick cluster of stems and small leaves will develop.

The egg-plant, as representing a slow-growing type of bushy plant, was employed for the test in question and it was found that this behaved in a manner similar to the radish, in that the petioles of the cotyledons became rigid and nearly upright, and bore the thick, almost fleshy, much enlarged oblanceolate blades well up in the air and sunshine. In this form the de-plumuled plants

will stand still in a very liberal sense of that term for an indefinite time, not weeks, but long months.

The last type of plant to be considered is represented here by the common sunflower (*Helianthus annuus* L.). As with the other types, the plants in alternate rows were de-plumuled. The first change was quickly observed, namely, the enlargement of the cotyledons ; but here the most noticeable thing observed was the elongation of the hypocotyl, which finally reached fully nine inches or double that of the normal plants. There is a greater tendency for hypocotyledonary growth in the sunflower than in any other of the types named, and this was remarkably accentuated in the mutilated plant. The structure of this stem, even at the end of three months, retained generally the primitive structure it possessed as a young seedling, that is, for example, the wood zone was made of a series of stout bundles, evenly disposed without the filling in and completion of the thick ring of xylem so well demonstrated in the normal plant at the same age.

The experiments illustrate how an organ normally designed to store food for the developing seedling may persist in case of an emergency and take on a greatly increased size for that purpose. The petiole may assume a direction in connection to its enlargement that will aid the blade in its work of photosynthesis. Along with these changes in the seed-leaves there may be others in surrounding parts, particularly the hypocotyl when it becomes thickened remarkably and green as in the morning glory and greatly elongated but slender as in the sunflower. In case of the radish a place for any surplus growth is provided for in the root, naturally destined to be fleshy and the hypocotyl is not modified.

Perhaps the greatest surprise is the length of time a plant will hold out when it is deprived of the means for making a successful struggle for life and of all possibility of reproduction.

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